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VERIFICATION OF A TRANSLATION

I, Susan ANTHONY BA, ACIS,

Director of RWS Group Ltd, of Europa House, Marsham Way, Gerrards Cross, Buckinghamshire, England declare:

That the translator responsible for the attached translation is knowledgeable in the French language in which the below identified international application was filed, and that, to the best of RWS Group Ltd knowledge and belief, the English translation of the international application No. PCT/FR2004/000105 is a true and complete translation of the above identified international application as filed.

I hereby declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the patent application issued thereon.



Date: June 30, 2006

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"METHOD FOR THE PRODUCTION OF PLANT CUTTING FILAMENTS HAVING NOVEL PROPERTIES, AND PLANT CUTTING FILAMENTS HAVING SUCH PROPERTIES"

- 5 The present invention relates in general to plant cutting apparatus such as grass trimmers, edge trimmers and the like, and aims more particularly at new cutting filaments for such apparatus.
- 10 A cutting filament is usually made by extrusion/drawing of polyamide, and significant advances in these filaments have been known for some years: shapes adapted to reduce noise, improve cutting efficiency, etc., strands made of several materials to improve
- 15 cutting efficiency, improving biodegradability, reducing cost, etc.

However, all the known filaments are still basically made by the same extrusion/drawing technique in which,

20 at a given stage of the process, or on several occasions, the filament at a temperature at which it has a controlled viscosity is subjected to a longitudinal stretching.

25 The consequence of this is to give the molecular chains an average orientation extending in the longitudinal direction of the filament, in order to give it a high tensile strength and limit breakages during work.

30 The object of the present invention is to offer the cutting filaments new possibilities of mechanical improvement based on a selective and controlled orientation of the molecular chains.

35 having elongated molecular chains, characterized in that it comprises the following steps:

- (a) bringing the filament to a state of controlled viscosity,

- (b) drawing the filament lengthwise to produce a first longitudinal molecular orientation,
- (c) imposing on the filament a change of cross section capable of partially reorienting the molecular chains in a transverse direction.

Certain preferred, but nonlimiting, aspects of this method are as follows:

- * the method also comprises the step consisting in:

- (d) imposing on the filament a second change of cross section capable of causing a second partial reorientation of the molecular chains in a transverse direction.

- * the second change of cross section is made in a general direction substantially identical to that of the first change of cross section.

- * the second change of cross section is made in a general direction substantially orthogonal to that of the first change of cross section.

- * the second change of cross section is made partially in a general direction substantially identical to that of the first change of cross section and partially in a general direction substantially orthogonal to that of the first change of cross section.

- * the filament has, before the implementation of step (c), a uniform cross section whose dimensions in two orthogonal directions are similar.

- * the step (c) comprises a flattening of the filament.

- * the step (d) comprises an at least local flattening of the filament.

- * the step (c) comprises a localized flattening and a localized thickening of the filament.
- 5 * the change of cross section, or at least the last change of cross section, of the filament is capable of forming a filament comprising a body and at least one wing protruding from the body.
- 10 * the change of cross section of the filament, or at least one of the changes of cross section, comprises forcing the filament through a series of dies of progressively different sections.
- 15 * the change of cross section of the filament, or at least one of the changes of cross section, comprises forcing the filament through a single die of variable section.
- 20 * the method also comprises a step of cutting the filament whose section has been changed into a plurality of individual subfilaments in the longitudinal direction of the filament.
- 25 According to a second aspect, the invention proposes a cutting filament for a plant cutting apparatus such as a grass trimmer or edge trimmer, the filament being made of a synthetic material with elongated molecular chains such as a polyamide, characterized in that, in
- 30 at least one zone of the cross section of the filament, the orientation of the molecular chains diverges from a longitudinal orientation.

Certain preferred, but nonlimiting, aspects of this
35 filament are as follows:

- * the filament comprises a body and at least one wing protruding from the body, and said wing forms a zone

in which the orientation of the molecular chains diverges from a longitudinal orientation.

* the wing has a generally triangular cross section.

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* in the body of the filament, the molecular chains are oriented essentially in the longitudinal direction of the filament.

10 * over most of its cross section, there are molecular chains oriented longitudinally and molecular chains oriented generally in a given transverse direction.

15 * over most of its cross section, there are molecular chains oriented longitudinally, molecular chains oriented generally in a first given transverse direction and molecular chains oriented generally in a second given transverse direction.

20 * the first and second transverse directions are essentially orthogonal to one another.

Other aspects, objects and advantages of the present invention will better appear on reading the following
25 detailed description of preferred embodiments of the latter, given as a nonlimiting example and made with reference to the appended drawings in which:

30 - figure 1 is a view in perspective of a cutting filament according to the prior art,

- figure 2 is a view in perspective of a cutting filament according to an exemplary embodiment of the invention,

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- figure 3 illustrates the evolution of a filament in terms of cross section and molecular orientation during the implementation of a manufacturing method according to the present invention, and

- figures 4 to 6 illustrate three examples of the implementation of a manufacturing method according to the present invention.

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Referring first of all to figure 1, it shows a cutting filament 10 for a grass trimmer, edge trimmer or similar element, which has in this instance a cross section that is square or somewhat like a flattened rhombus. Here it is made of polyamide 6 (PA6).

10

This filament has been manufactured by a conventional extrusion/drawing method, in which the filament, in a given state of viscosity (determined by controlling its temperature), has undergone a longitudinal drawing in a determined drawing ratio, so that the molecular chains of polyamide have mostly adopted an orientation 01 in the longitudinal direction of the filament.

15

This conventional method makes it possible to obtain cutting filaments which, due to this molecular orientation, have an excellent tensile strength, and therefore a resistance to shearing during the work of cutting plants.

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Figure 2 illustrates a cutting filament made according to the invention. In this filament, there are a body part 11 and two wings 12, 13 situated laterally on either side of the body.

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Via a method such as will be detailed hereinafter, the filament has:

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- in its central region, mainly at the body 11, a longitudinal molecular orientation 01, in the same manner as in the filament 10 of the prior art shown in figure 1;

- in the region of at least one of its wings (here the wing 12 that is most prominent), a molecular orientation 02 that is mainly oriented transversely to the longitudinal direction of the filament.

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Thus, thanks to this double orientation, the cutting filament has enhanced mechanical properties, with a plant cutting region furnished with a mainly transverse molecular orientation, hence a better resistance to wear by transverse wrenching of the filament material, and a body region retaining a mainly longitudinal molecular orientation, to retain overall a good tensile strength.

15 It will be observed here that, in the opposite wing 13, there is an intermediate molecular orientation between the longitudinal and transverse orientations.

It will also be observed that the working part 12 of the filament may be furnished with arrangements (teeth, specific anti-wear coating, etc.) designed to enhance the properties of the filament particularly with respect to cutting efficiency.

25 Figure 3 illustrates the behavior of the filament during the implementation of a method according to the present invention.

A conventional extrusion/drawing method with circular die has made it possible to culminate in a cutting filament as illustrated in its phase 101, with a circular cross section and a mainly longitudinal molecular orientation 01.

35 Thanks to a set of dies producing a sort of mixing of the filament still in the viscous state, phase 102 culminates in a filament with a generally square cross section with rounded corners, in which the molecular orientation, although remaining mainly longitudinal,

has begun to diverge from this direction. A new set of dies transforms the cross section of the filament from its generally square phase to a phase 103 that is, for example, that corresponding to the end product of figure 2.

During this operation, and owing in particular to the disorientation begun in the preceding step and the limited thickness of the lateral wing 12 of the filament, the molecular chains in this region have taken on a mainly transverse orientation 02 resulting from the progressive creep of the filament material toward this region.

This produces a filament corresponding to that of figure 2.

It will be observed here that, instead of a set of dies of constant section gradually bringing the transverse section of the filament from one shape to another, it is possible to provide dies of changing section to culminate essentially in the same type of result.

Figure 4 illustrates a first concrete application of a method according to the present invention.

The point of departure is a filament 10 of square cross section obtained by a conventional extrusion/drawing method, resulting in a molecular orientation 01 that is mainly longitudinal.

This filament has, for example, a section of 4.5 x 4.5 mm.

In step 401, this strand enters a die 20 in two parts 21, 21 made identically and one of which is symmetrical with the other relative to a horizontal mid-plane.

Thus, each die part has a main working surface 211 that is substantially flat, in the middle of which a slight circular indentation 212 is formed.

- 5 The spacing between the two parts 21, 21 is initially such that the distance between the facing working surfaces is substantially equal to the height of the filament 10.
- 10 These two parts of the die are placed on the production line to come progressively closer to one another until there results the situation corresponding to step 402. Between steps 401 and 402, the filament is in a controlled state of viscosity, has been compressed
- 15 vertically, causing a lateral creep of its material and hence a partial transverse (or oblique) reorientation of the molecular chains of the polyamide 6. In the present example, the general dimensions of the transition defined by the die in step 402 are
- 20 approximately 1.75 x 8 mm.

The section of the filament is then again worked to pass from the die illustrated in step 402 to a die 22 as illustrated in connection with step 403, either in

25 steps, or progressively in a variable geometry die.

Here again the die 22 comprises two identical parts 23, 23 that are symmetrical relative to a horizontal mid-plane, with a flattened V-shaped indentation 231 over

30 the whole width and, at the base of this flattened V, a narrower channel 232 with a semicircular base.

This shape causes, on the one hand, a thinning of the lateral regions of the filament to a triangular shape,

35 and, on the other hand, a thickening of its central region (whose dimensions are approximately 4 x 1.75 mm in the present example).

This has the effect of further accentuating the transverse orientation 02 given to the molecular chains of polyamide in the lateral regions of the filament. At the same time, it is observed that the central region
5 of the filament has undergone, on the one hand, from step 401 to step 402, a horizontal flattening then, from step 402 to step 403, a flattening in the vertical direction, which has the effect of creating, in this region, a molecular multi-orientation favorable to the
10 mechanical strength of the filament not only in its longitudinal direction but also in all the transverse directions.

This makes it possible in particular to reduce, or even
15 eliminate, the phenomena of fraying of the cutting filament at its free end.

Figure 5 illustrates a second exemplary embodiment of the method according to the invention, which aims to
20 produce a cutting filament having the same contour as in the preceding example, but with further enhanced properties.

In this example, steps 501 and 502 are identical to
25 steps 401 and 402 of the preceding example. After step 502, the filament is rotated through 90° before being engaged in a die 22 identical to that described with reference to figure 4, but whose two elements have been spaced further apart to be able to receive the
30 flattened filament, then oriented vertically (step 503).

As a variant, the filament 10 retains its orientation but the die 22 is turned 90° relative to the
35 illustration of figure 5.

The two parts of the die 22 are then brought progressively closer together (steps 504 and 505) in order therefore for the filament to be worked in a

direction perpendicular to that in which it was worked between steps 501 and 502. As an example, the total height of the filament changes from approximately 8 mm (step 503) to approximately 4 mm (step 505).

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The filament obtained at the end of step 505 has, in terms of contours, the same shape as that obtained at the end of step 403 of figure 4; the essential difference was the fact that it undergoes a double
10 thinning, in two orthogonal directions (knowing that, as a variant, two directions that are oblique relative to one another can be provided).

The multi-orientation of the polyamide molecules is
15 this accentuated.

Figure 6 illustrates another embodiment of the invention, which uses a die 24 with two elements 25 having flat facing surfaces 251.

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In step 601, a filament 10 of generally square section is received between the two parts 25 of the die 24. Between steps 601 and 602, the two parts of the die are brought closer together, to culminate in a generally
25 flat filament, whose thickness is, for example, between 2 and 4 mm, and whose width is typically equal to several times this thickness. During this operation, the orientation of the molecular chains has been partly transformed into a lateral orientation 02, as
30 illustrated in step 602.

In step 603, the flattened filament, after being taken out of the die 24, is cut up with the aid of appropriate blades (not shown) into a plurality of
35 filaments having the same height, but a reduced width. In the present example, this step produces four individual filaments 10a to 10d, with a generally square cross section. The small terminal parts 15 or 16 are scrapped or recycled.

In each filament, the molecular chains have an orientation that is no longer solely longitudinal. This provides better mechanical properties, particularly
5 less tendency to fray, without undesirably degrading the tensile strength in the longitudinal direction.

According to a variant (not shown) of this embodiment, a first flattening of the filament can be achieved as
10 in step 602, and a second flattening in an orthogonal direction (in the same spirit as in the embodiment of figure 5), in order to further accentuate the disorientation of the molecular chains of polyamide by carrying out this disorientation in an additional
15 direction.

It will be noted here that the square section filaments obtained in step 603 may be either packaged for marketing as is, or undergo any other treatments, and
20 particularly shaping treatments (formation of cutting teeth, etc.), coating, etc.

Naturally, the present invention is in no way limited to the embodiments described hereinabove and shown in
25 the drawings, but those skilled in the art will be able to apply many variants and modifications thereto.

In particular, it is understood that the invention may be combined by those skilled in the art with many other
30 enhancements generally known in the field of cutting filaments (filaments of a particular shape and/or poly-materials to enhance cutting efficiency, reduce operating noise, improve biodegradability, prevent sticking phenomena, etc.).